SPECIFICATION

TITLE OF THE INVENTION

PACKING MATERIAL AND GLAND PACKING USED THE MATERIAL

BACKGROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a packing material and gland packing used the material, more detail, the present invention relates to a gland packing and its material, which has enough durability even if it is used not only under normal temperature and low pressure but also under high temperature and high pressure. In each case, the gland packing can keep high lubricating property over the long term, and the gland packing can be used for both a valve and a pump. Further, by using the gland packing, other type of gland packing does not need to be used in a stuffing box.

In the specification, allowable tensile force means the product of a tensile strength (kgf/cm^2) of the materials, and the cross-sectional area (cm^2) of the materials in a case of the materials resulting in a fracture.

2. Description of the Related Art

As a gland packing which seals a shaft of a fluid machinery such as a pump or valve, there is a gland packing which is made from asbestos, carbonized fibers, carbon fibers, and aramid resin fibers.

Further, there are gland packings which are comprised above-mentioned materials which are involved PTFE (For example, Tokukaihei 6-101764). These gland packings are packed in a space which

is made in-between a shaft and an apparatus casing, i.e., the inside of the stuffing box, in order to prevent fluid from leaking out from in-between the shaft and the apparatus casing.

Required performance of the gland packing is slightly different between the pump and valve. In sealing of a shaft of the pump, at first, high lubricating ability is required so as not to prevent high velocity revolution of the shaft, and then high sealing ability and pressure resistance ability are required. Some leaking of fluid is allowed, because the leaking let frictional heat out.

On the other hand, in a sealing of a shaft of the valve, at first, high sealing ability and pressure resistance ability are required so as not to leak high pressure fluid, and then, high lubricating ability is required. Since the shaft of the valve rotates around the shaft and linearly goes and return, the shaft of the valve has been protruded in a gap between the shaft and a roller bearing by changing the shape of a part of a packing, and running torque of the shaft rapidly accelerates by the protrusion. Therefore, pressure resistance ability is very important in the packing for the valve.

The conventional gland packing cannot harmonize all of lubricating ability (low torque ability), pressure resistance ability and heat resistance at a high level, and the gland packing cannot be used long term under very high pressure and high temperature (for example, as a valve for a generating power plant).

BRIEF SUMMARY OF THE INVENTION

The present invention is invented in consideration of these cases, its

purpose is to provide a gland packing and its material that have enough durability even if it is used not only under normal temperature and low pressure but also under high temperature and high pressure, and in each case, the gland packing and its material can keep high lubricating property over the long term, and it can be used for both a valve and a pump. Further, the purpose of the present invention is to provide the gland packing that other type of gland packing does not need to be used in a stuffing box.

The present invention described in claim 1 is a packing material comprising an expansive graphite tape is mounted on one or both sides of plain state carbon fiber to make a first laminated tape, and it is twisted to be a filament, and to make a second laminated tape, an expansive graphite sheet is mounted on one or both sides of a reinforcing material comprising plural reinforcing fibers or reinforcing wires aligned in approximately parallel each other or a reinforcing material which a woven is cut into a strip, and said second laminated tape is wound around said filament.

The present invention described in claim 2 is the packing material described in claim 1, wherein to make a third laminated tape the expansive graphite tape is mounted on one or both sides of the plain state carbon fiber, and instead of said second laminated tape, the third laminated tape is wound around said filament.

The present invention described in claim 3 is the packing material described in claim 1, wherein the filament is made by twisting the first laminated tape so that a reinforcing core is covered with the first laminated

tape.

The present invention described in claim 4 is the packing material described in claim 2, wherein the filament is made by twisting the first laminated tape so that a reinforcing core is covered with the first laminated tape.

The present invention described in claim 5 is a gland packing made into a predetermined shape by pressing a braided material comprising the braided packing material described in claim 1.

The present invention described in claim 6 is a gland packing made into a predetermined shape by pressing a braided material comprising the braided packing material described in claim 2.

The present invention described in claim 7 is a gland packing made into a predetermined shape by pressing a braided material comprising the braided packing material described in claim 3.

The present invention described in claim 8 is a gland packing made into a predetermined shape by pressing a braided material comprising the braided packing material described in claim 4.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a view showing a filament in a first embodiment of the present invention.

Figure 2 is a view showing a twisting of the filament showing in Figure 1, and a view showing a first laminated tape which is twisted.

Figure 3 is a cross sectional view showing the first laminated tape and mounted materials used in order to make the first laminated tape of present

invention.

Figure 4 is a view showing other example of the filament in a first embodiment.

Figure 5 is a view showing a twisting of the filament shown in Figure 4, and a view showing the first laminated tape so that it is twisted to cover a reinforcement wire rod which is mounted at the central of the filament.

Figure 6 is a view showing a making of a packing material which relates to the first embodiment, and a view showing a winding of a second laminated tape around the filament.

Figure 7 is a cross sectional view cut in the width direction showing the second laminated tape of the present invention, and (a) is a view showing a mounting of an expansive graphite tape on one side of reinforcing material, and (b) is a view showing a mounting of the expansive graphite tape on both sides of the reinforcing material.

Figure 8 is a view showing a braiding of the packing material which relates to the present invention.

Figure 9 is a view showing a braiding of the packing material which relates to the present invention.

Figure 10 is a view showing a braiding of the packing material which relates to the present invention.

Figure 11 is a view showing a braiding of the packing material which relates to the present invention.

Figure 12 is a view showing a gland packing which relates to the present invention.

Figure 13 is a view showing a packing material which relates to the second embodiment, and (a) is a perspective view showing a partially dissolving of the packing material, and (b) is a A-A line sectional view of (a).

Figure 14 is a graph showing a number of sliding of a shaft in a performance test of the packing.

Figure 15 is a graph showing a result of a leakage test.

Figure 16 is a graph showing a result of a sliding resistance test (in change of direction in back-and-forth motion).

Figure 17 is a view showing a result of a sliding resistance test (in change of direction in one way).

Figure 18 is a view showing a result of a bearing test.

Figure 19 is a schematic sectional view of a packing material which relates to a comparative example 1.

Figure 20 is a view showing a schematic sectional view of a packing material which relates to a comparative example 2.

DESCRIPTION OF PREFERED EMBODIMENTS OF THE INVENTION

Hereinafter, the present invention is explained with referring to the drawings.

At first, a packing material which relates to the first embodiment of the present invention is explained.

Figure 1 is a view showing a filament in a first embodiment of the present invention. Figure 2 is a view showing a twisting of the filament showing in Figure 1, and a view showing a first laminated tape which is twisted. Figure 3 is a cross sectional view showing the first laminated tape

and mounted materials used in order to make the first laminated tape of the present invention.

The gland packing of the present invention (1) (refer to Figure 12) is braided a filamentous packing material (2) (refer to Figure 6), and the braided body (3) (refer to Figure 8 to 11) is pressed to a predetermined shape.

The packing material (2) which relates to the first embodiment (refer to Figure 6) is made from at first, a filament (20) which is made by twisting a first laminated tape (4) which is made by mounting an expansive graphite tape (6) on one side or both sides of a plain state carbon fiber (7) (refer to Figure 2 and 3). A second laminated tape (12) (refer to Figure 6 and 7) is made by mounting an expansive graphite tape (60) on one side (refer to Figure 7 (a)) or both sides (refer to Figure 7 (b)) of a reinforcing material which is made by cutting a fabric into a strip or the reinforcing material (11) which is made by placing plural reinforcing fibers or plural reinforcing wire) (10) (refer to Figure 7) approximately parallel, and the second laminated tape (12) is winded around said filament (20).

Figure 2 shows a first laminated tape (4) which is twisted. The first laminated tape (4) is made by cutting a laminated sheet (5) shown in Figure 3 like strip. The laminated sheet (5) is made by mounting plain state carbon fiber (7) on an expansive graphite sheet (61) with an adhesive layer (8). The adhesive layer (8) has two functions as adhesive and function as reinforcing material.

The type of the adhesive layer (8) is not particularly limited and can

be made from organic adhesives, inorganic adhesives and mixture of organic and inorganic adhesives and the like. The adhesive layer (8) can be taken form of liquid, emulsion, film, non-woven fabric and the like. Further, a mounting method of adhesives is not limited, and it can be selected from application, thermocompression bonding, spray and such.

It is desirable to use water soluble thermal plasticity adhesives, and it is more desirable to use non-polluting polyvinyl alcohol for the adhesive layer (8). Polyvinyl alcohol can be used by applying to a surface of the expansive graphite sheet (6) or carbon fiber by keeping the polyvinyl alcohol liquid or by blasting. When the adhesive layer (8) is mounted by blasting, for example, it can be mounted as sort of non-woven fabric.

When polyvinylalcohol (hereinafter referred to as PVA) is used to the non-woven fabric, the adhesive layer (8) is mounted that PVA resin fibers extend to irregular direction, and a sheet is made by fixing the PVA resin mutually. The adhesive layer (8) has great tensile strength against tensile force in any directions, and especially in a condition where the adhesive layer (8) is made to be a strip, it shows great tensile strength against tensile force from the axial direction.

In gluing the expansive graphite sheet (61) and the plain state carbon fiber (7), these can be strongly mounted by intervening the PVA adhesive layer (8) between the expansive graphite sheet (61) and the plain state carbon fiber (7) and by pressuring from both sides or by pressuring with heating.

As the expansive graphite sheet (61), after making an interlayer

compound by reacting graphite powder such as natural graphite and kish graphite with concentrated sulfuric acid, concentrated nitric acid and the like, the residue of the compound is gained by a water bathing, and it is expanded by a quick heating so that to gain expansive flexible graphite, and the expansive flexible graphite is molded with compression with a rolling material so that to make a sheet shape.

The density of the expansive graphite sheet (61) is not limited particularly, but it is preferred 0.80 ~ 2.2 g/cm^3. When the density is in this range, unevneness in crystal level is made on the surface of the expansive graphite sheet (61), and it can cause an anchor effect to the mounted material thereon. On the other hand, when the density is less than 0.80 g/cm^3, texture of organization becomes too rough, leading a lowering of sealing ability of packing being made. Further, when the density is more than 2.2 g/cm^3, there is a possibility that the texture of organization becomes too fine to cause the anchor effect, and not to satisfactorily laminate with the plain state carbon fiber (7).

Furthermore, the thickness of the expansive graphite sheet (61) is not limited particularly, but it is preferred 0.10 ~ 1.5 mm, and more preferably it is 0.12 ~ 0.2 mm. When the thickness is less than 0.10 mm, outstanding heat resistance, corrosion resistance, and abrasion resistance of the expansive graphite cannot be manifested. Further, such a thin expansive graphite sheet is uneconomical because of difficultness of manufacture. On the contrary, when the thickness of the expansive graphite sheet is more than 1.5 mm, brittleness of expansive graphite

appears.

The plain state carbon fiber (7) functions to reinforce the expansive graphite sheet (61), to cover for elasticity and to roll a solid lubricant material. The plain state carbon fiber (7) is mounted on a surface of the expansive graphite sheet (61) with the adhesive layer (8). The plain state carbon fiber (7) is mounted with using the mounting method as mentioned-above. In case of a heat anastomosis film is used as adhesive, for example, a PVA plain state fabric, PVA film, polyethylene film, olefin film and urethane film can be used.

The plain state carbon fiber (7) is a strip fabric aggregation which properly raxes a strengthen fabric such as a carbon fiber from the original width to necessary width.

The plain state carbon fiber (7) surpasses in physical strength, and hardly changes its property such as physical strength between −200°C ~ +600°C, so it also surpasses properties of under low temperature and high temperature. Therefore, the plain state carbon fiber (7) can be surely reinforced the expansive graphite sheet (61) under circumstance of severity temperature as well as ordinary temperature. Further, since the plain state carbon fiber (7) has outstanding lubricating and sealing ability, it can obtain the packing (1) having outstanding lubricating and sealing ability by constructing braiding thread as the plain state carbon fiber (7) is positioned outside the packing (1). Moreover, since plain state carbon fiber (7) surpasses in corrosion resistance and abrasion resistance, it can be used long-term even under harsh environment, such as a chemical plant.

It is desirable that the thickness of the plain state carbon fiber (7) is 0.01 ~ 0.5 mm, and it is more desirable 0.15 ~ 0.2 mm or 0.01 ~ 0.02 mm. In case of the thickness is less than 0.01 mm, it cannot obtain enough lubricating and sealing ability, on the other hand, in case of the thickness is more than 0.5 mm, the plain state carbon fiber (7) cannot obtain enough flexibility.

The manufacturing method of the plain state carbon fiber (7) is not limited particularly, a fiber (carbon fiber) called multifilament can be thin and wide plain state by using for example, supersonic or fluid flow. Thickness of the plain state carbon fiber (7) is preferably plain-woven several dozen μm or less than, for example, width is more than 25 mm and thickness is less than 20μm.

In a manufacturing process of the first laminated tape (4), there is a process of cutting the laminated sheet (5) like a strip, each fiber of the plain state strip carbon fiber is equally arranged with high density, and big frictional force works in each fiber.

Therefore, each fiber is interconnected tightly along the axial direction and right angle direction against the axial, the first laminated tape (4) becomes a strip which has big tensile strength. Usually, a plain state carbon fiber is made by gathering various length carbon fibers to constant direction and closing up. That is, various length carbon fibers are mounted in the axial direction and right angle direction against the axial. In these aggregation of fibers, as mentioned-above, each fiber is interconnected with big tensile force each other. Therefore, the

aggregation can be a durable strip, even if it is cut on the cross.

A width of the first laminated tape (4) is 5 ~ 30 mm, and preferably it is 5 ~ 25 mm. When the width is more than 30 mm, flexibility of the first laminated tape (4) comes down, and it becomes difficult to fabricate to a filament. Conversely, when the width is less than 5 mm, tensile strength of the first laminated tape (4) comes down extremely, and the first laminated tape (4) may fracture when it is processed into the filament (20). In case of the width is 5 ~ 30 mm, the first laminated tape (4) is in no risk of fracture when it is twisted, because it has enough tensile strength.

The first laminated tape (4) can be made relatively thin, because it is reinforced by the plain state carbon fiber (7) fibersand adhesive layer (8). Therefore, not only the first laminated tape (4) which has 5 ~ 10 mm width but also the first laminated tape (4) which has more than 10 mm width can have enough flexibility. When the filament (20) is made by using the first laminated tape (4) of 5 ~ 10 mm width, a cord (3) used a number of cord such as twenty four or thirty two can be made. Further, the cord (3) used a number of cord can be made from the filament (20) which has various thickness. By this, a packing (1) which has high sealing ability can be obtained, because a cord (3) which is dense of its inside.

The first laminated tape (4) is twisted to be the filament (20). When the first laminated tape (4) has the expansive graphite sheet (6) at only one side of the plain state carbon fiber (7), in a twisting of the first laminated tape (4), the plain state carbon fiber (7) is mounted outside or the expansive graphite sheet (6) is mounted outside. Each case is available,

but in case of the plain state carbon fiber (7) is twisted so that it is mounted inside, when the packing is made, a part of the plain state carbon fiber (7) is not exposed on exterior surface of the packing.

A twisting method of the first laminated tape (4) of the present invention is not limited particularly, but a method which twists tightly the first laminated tape (4) which is folded at center of width direction or a method which twists the first laminated tape (4) without folding (refer to Figure 2) can be employed.

The preferable twisting numbers are about 55 ~ 70 per 1 m. With this numbers of twisting, the inventor has found that the strength of the filament (20) becomes extremely high.

The plain state carbon fiber (7) made by the plain state carbon fiber such as carbon fiber multifilament surpasses lubricating ability, abrasion resistance, corrosion resistance, physical strength and sealing ability. Therefore, by using the plain state carbon fiber (7) as a packing material, it can obtain a packing (1) which surpasses lubricating ability, abrasion resistance, corrosion resistance, physical strength and sealing ability.

Since the filament (20) surpasses in flexibility, a complicated braiding can easily be carried out, and even when carrying out a complicated processing, a laminated sheet (4) does not fracture. Also, there is no risk of fracturing during a braiding, because the first laminated tape (4) which makes the filament (20) has enough allowable tensile force.

Furthermore, the filament (20), as shown in Figure 4 and Figure 5, can be comprised from a structure with a reinforcing core (9). To be more

precise, as shown in Figure 5, the filament (20) can comprise a structure that the first laminated tape (4) is twisted around the reinforcing core (9) so that the first laminated tape (4) covers the reinforcing core (9). In such case, allowable tensile force of the filament (20) can increase more than it is made from the first laminated tape (4) only. The material of the reinforcing core (9) is not particularly limited, but any materials can suitably be used if it has enough strength as a packing material, for example, metal such as Monel metal, inconel, ferrochrome, stainless, copper and aluminum, glass fiber, ceramic fiber, synthetic resin such as aramid resin, polytetrafluoroethylene resin (PTFE), nylon resin, acrylate resin and phenol resin, material that soaks lubricating oil to these synthetic resin, carbide of these synthetic resin and asbestos.

It is preferable for the reinforcing core (9) to have its diameter 0.15 ~ 0.3 mm, and more preferable the diameter is 0.25 mm. If the diameter is such length, the first laminated tape (4) can easily be twisted.

Additionally, the reinforcing core (9) can be used singly, but plural reinforcing core (9) can also be used as described below. If a single reinforcing core (9) is used, for example, it may be used without braiding, or it may be used as a cord which was braided. Further, if plural reinforcing cores (9) are used, these may be used by braiding together, or these may be used as a cord which has been braided.

The sectional form of each wire which makes the reinforcing core (9) is not particularly limited, for example, it can take many configurations such as orbicular section, rectangle section and elliptical section and such.

The second laminated tape (12) is made by mounting the expansive graphite tape (60) on one side or both sides of a reinforcing material (11) comprising plural reinforcing fibers or plural reinforcing wires (10), or a strip reinforcing material made by cutting woven.

The second laminated tape (12) performs as a solid lubricant and as a reinforcing material, and also prevents the plain state fiber from sticking out of the surface of the packing material (2) as like mustache.

When the plain state fiber sticks out of the surface of the packing material (2), a gland packing by a pressuring the packing material (2) will also have the fibers sticking as like mustache on its surface. The fibers sticking out could facilitate early worn-out of a shaft such as a rotating shaft, which could result in leakage of fluid.

The reinforcing material (11) may comprise plural reinforcing fibers, plural reinforcing wires (10), or by cutting a woven into a strip.

Although the material of the reinforcing fibers, the reinforcing wires (10) and the woven is not particularly limited, for example, the reinforcing wires could comprise Monel metal, inconel, stainless steel, copper or aluminium, and the reinforcing fiber could comprise glass fibers, ceramic fibers, synthetic resin comprising aramid resin, polytetrafluoethylene resin (PTFE), nylon resin, acryl resin, phenolic resin and etc, carboniser of fibers comprising these synthetic resin (carbon fiber) or asbestos. Cotton woven could be used for a reinforcing material.

If the reinforcing material (11) comprises the reinforcing fibers or reinforcing wires (referring to Figure 7), a strip reinforcing material (10)

will be made by aligning the plural reinforcing fibers or the plural reinforcing wires (11) side by side each other and their whole configuration forming a strip.

The second laminated tape (12) is made by mounting the expansive graphite tape (60) on one side or both sides of the strip reinforcing material (11). Any type of adhesive can be used to combine the strip reinforcing material (11) with the expansive graphite tape (60).

Although the thickness of the second laminated tape (12) is not particularly limited, it can be, for example, 0.2 mm when applying the expansive graphite tape (60) on one side of the reinforcing material (11), and 0.35 mm with the expansive graphite tape on both sides of the reinforcing material (11).

Although the width of the second laminated tape (12) is not particularly limited, preferably it is 10 ~ 20 mm in width, and more preferably 15 mm in width.

When the second laminated tape (12) exceeds 20 mm in width, its flexibility goes down, which makes it harder to wind around the first laminated tape (4), and this results in uneven width where the tape is overlapped in winding it. On the other hand, when the second laminated tape (12) is less than 10 mm in width, the second laminated tape (12) could be broken out in winding because the allowable tensile strength of the second laminated tape (12) extremely goes down.

The second laminated tape (12) is wound one time or twice around the outer surface of the filament (20) (Figure 6 shows one time winding).

Winding the second laminated tape twice further enhances lubricating ability and sealing ability of the packing material (2). In winding the second laminated tape (12) twice, winding one of the second laminated tape (12) to the opposite direction from winding the other second laminated tape (12) provide equivalent durability and sealing ability with a shaft rotating clockwise or anti-clockwise.

Preferably the second laminated tape (12) is wound so that its side edge overlaps with the adjacent side edge of the tape (12).

In the case of the second laminated tape (12) having the expansive graphite tape (60) applied on just one side of the reinforcing material (11), the second laminated tape (12) is preferably wound around a filament (20) so that the reinforcing material (11) will stay inside, in order to prevent the reinforcing material (11) from being exposed on the outer surface of the packing made.

A cord (3) in forms of knitted cord, braided cord, plaited cord and such can be made by braiding with such packing material (2) gained. To be more precise, by braiding with one or plural pieces of the packing material (2), a cord in forms of knitted cord such as a roundly knitted cord and a squarely knitted cord, and braided cord (3) such as a roundly braided cord and a squarely braided cord can be made. In addition to these, a cord (3) in a shape of a double braided cord or a fasten cord can be made. In the case of braiding cords, a spontaneous braiding method wherein four, eight, sixteen or eighteen, twenty four or thirty two of the braiding thread can be used.

The expansive graphite tape is wound outside of the cord (3).

When PVA is used as an adhesive layer (8), it will be stayed inside of the cord (3), but the PVA layer can be removed after making the cord (3). Although the PVA layer surpasses as a reinforcing material, as it has a characteristic which may easily cause a stress relaxation, removing of this layer results in no stress relaxation to occur to the cord (3). This also results in no stress relaxation in the packing (1). Additionally, when a reinforcing material is necessary is when the greatest tensile force acts to the expansive graphite sheet (6), i.e., when the filament (20) and the cord (3) are made. Therefore, there will be no problem even if the PVA layer is removed after constructing the cord (3).

When removing the PVA layer, soaking of liquid resin to the cord (3) is preferable. This is for a portion at where the PVA layer existed to make a space when removing the PVA layer. If the cord (3) is soaked in the liquid resin, the space can be filled with the liquid resin. By filling the space with the liquid resin, passing through of fluid from the inside of the cord (3) can be prevented when using the packing (1) inside of the stuffing box. Therefore, sealing ability of the packing (1) can be enhanced.

As for the liquid resin for soaking the cord (3), for example, fluorocarbon resin such as polytetrafluoethylene (PTFE), silicone resin, water-soluble phenolic resin, and emulsion resin including inorganic pulverized powder such as glass, alumina, silica gel, micromica, graphite and titanium can be used. Also, for the cord (3), more than one or two liquid resin selected from a group comprising these liquid resins can be

soaked into. As a soaking method, for example, normal soaking, soaking with heat or soaking in vacuum can be employed.

The packing (1) can be gained by a pressuring of this cord (3). The packing (1), for example, as shown in Figure 12, is made in a ring shape. The ring-formed packing (1) is packed into a stuffing box and used suitably as a packing for shaft sealing of fluid apparatus. The packing (1), as aforementioned, has a structure wherein the expansive graphite tape (60) positions on the surface thereof. Therefore the packing (1) can be made to have outstanding lubricating ability, sealing ability, abrasion resistance, physical strength and corrosion resistance.

When the gland packing (1) comprises the packing material (2) without the reinforcing core (9), this gland packing (1) can be generally used for pressured fluid at 150 ~ 2,500 psi (e.g., packing for a valve), and have sufficient durability and lubricating ability (for lower torque) under this condition. An example of the use of the packing for pressured fluid at 1,500 psi is for petroleum factories or petroleum/chemistry factories. An example of that for pressured fluid at 2,500 psi is for atomic power stations.

When the gland packing (1) comprises the packing material (2) with the reinforcing core (9), this gland packing can be generally used for pressured fluid at 150 ~ 4,500 psi (e.g., packing for a valve), and have sufficient durability and lubrication (for lower torque). An example of the use of the packing for pressured fluid at 4,500 psi is for thermal power stations.

In above-mentioned every embodiment, the gland packing (1) has

sufficient lubricating ability and durability even if it is used for any fluid apparatus (e.g., pump) in which a shaft rotates at high speed (more than 25 m/sec at the surface of the rotation shaft).

The following is to explain the second embodiment of the present invention. Figure 13 shows a packing material described in the second embodiment.

The packing (2) described in the second embodiment is made by winding a third laminated tape (21) around the filament (20) used in the first embodiment, which is made by mounting the expansive graphite tape (6) on one side or both sides of the plain state carbon fiber (7), instead of the second laminated tape (12) in the first embodiment.

The filament (20) can be the same as that used in the first embodiment.

Use of the third laminated tape (21) is the same as that of the first laminated tape (4).

In the case of the third laminated tape (21) comprising the expansive graphite tape (6) mounted on just one side of the plain state carbon fiber (7), it is preferable that the third laminated tape (21) is wound so that the plain state carbon fiber (7) will stay inside, in order to prevent the plain state carbon fiber (7) from being exposed outside of the packing made.

Similarly to the first embodiment, the filament (20) may have a construction wherein the filament (20) is twisted so that the filament (20) covers the reinforcing core (9). The material of the reinforcing core (9) can

be the same as that in the first embodiment.

The packing (2) in the second embodiment also delivers equivalent advantages to what the packing in the first embodiment delivers.

Embodiment

Effects of the present invention will be clarified by description of the embodiment for the packing material of this invention. The packing material of the present invention is not limited to the following embodiment.

Embodiment

The packing material of the present invention is made as the following, and the gland packing of this embodiment is obtained by pressuring of the packing material. In this embodiment, the packing material of the second embodiment is made.

At first, the first laminated tape is made by mounting and unifying an expansive graphite tape on the both sides of a plain state carbon fiber, and then the first laminated tape is twisted so that the first laminated tape covers the reinforcing core, which results in a filament.

An inconel wire is used for the reinforcing core, which is 0.25 mm in diameter.

The plain state carbon fiber is 0.02 mm in thickness and 20 mm in width.

The expansive graphite tape is 0.2 mm in thickness and 20 mm in width.

After that, the third laminated tape is gained by mounting an

expansive graphite tape on one side of a plain state carbon fiber made from plain woven, and then the third tape is wound around the filament, which results in a packing material, of which cross-section is square, wherein the third laminated tape is wound so that the expansive graphite tape stays outside. Each side of the square packing material is 6.5 mm in length.

The plain state carbon fiber used in the third laminated tape has the same thickness and width as that used in the first laminated tape, and also the thickness and the width of the expansive graphite tape used in the third laminated tape is the same as those used in the first laminated tape.

Finally, the packing material is braided and pressured, which results in a ring-shaped gland packing.

Comparative Test 1

Figure 19 is a schematic cross-sectional view of the packing material used in Comparative Test 1.

As shown in Figure 19, a packing material (32) is made by covering a cord (33) which is made by mounting expansive graphite tapes with inconel wires (31). The cross-section of the cord (33) is square, and each side of the packing material is 9.38 mm in length. The inconel wire is 0.12 mm in diameter. Each side of the square packing material (32) is 9.5 mm in length.

After that, the packing material (32) is braided and pressure made, which results in a ring-shaped gland packing.

Comparative Test 2

Figure 20 is schematic cross-section of the packing material used in

Comparative Test 2.

As shown in Figure 20, a packing material (37), of which cross-section is square, is made by braiding filaments (36), wherein inconel wires (35) are braided around and covers a thinly sliced expansive graphite tape (34). The expansive graphite tape is 0.29 mm in thickness, and its width after sliced is 6.5 mm. The inconel wire is 0.10 mm in diameter, and each side of the square packing material (37) is 9.5 mm in length.

After that, the packing material (37) is braided and pressure made, which results in a ring-shaped gland packing.

(Test Method)

The ring-shaped gland packing of the embodiment, Comparative Test 1 or Comparative Test 2 is packed into a stuffing box. Sealing ability, lubricating ability and pressure resistance of each gland packing with a shaft (a valve shaft) passing through the packing is tested by sliding the shaft back and forth repeatedly.

Leakage for sealing ability, resistance against sliding of the shaft for lubricating ability (changing the direction of sliding and one way sliding) and change in pressure between the packing and the shaft for pressure resistance are checked.

The number of 1 cycle of sliding back and forth is 2,500, and 6 cycles are repeated, in total 15,000 times of sliding back and forth (refer to Figure 14). Hot water is used in each test as pressure fluid. The temperature in the stuffing box is 350°C. In regard to the shaft movement, the stroke of the movement is 50 mm, and the speed of the movement is 25 mm/sec, and

idling time at the end of the movement is 1 sec, and number of repeat of the movement is 2,500 × 6 cycles as aforementioned.

The result of each experiment is shown in Figure 15 to Figure 18. Figure 15 shows leakage, Figure 16 shows resistance against sliding at change in the direction of the shaft movement, Figure 17 shows resistance against sliding during one way moving of the shaft and Figure 18 shows change in pressure between the packing and the shaft.

(Test Result)

As the leakage data shown in Figure 15, the leakage is consistently close to zero with the gland packing of the embodiment during experiment, on the other hand, the leakage is consistently higher with that of Test 1. The leakage with the gland packing of Test 2 starts after 5,000 times movement of the shaft and it is rapidly grown up. Therefore, the gland packing of the embodiment has better and longer lasting sealing ability than other gland packings under high temperature and high pressure.

As the data of resistance against sliding of the shaft in Figure 16 and Figure 17, the resistance against sliding of the shaft with the gland packing of the embodiment is consistently lower than that with the gland packing of Test 2, and after 1,500 times movement of the shaft, the resistance of the embodiment is certainly lower than that of Test 1. The difference of the resistance between the embodiment and Test 1 grows up as the number of the shaft movement. Therefore, the packing of the embodiment has better and longer lasting lubricating ability than the others under high temperature and high pressure.

As the data of change in pressure between the packing and the shaft in Figure 18, the pressure between the packing and the shaft of the embodiment is consistently higher than the others. Therefore, the gland packing of the embodiment has better and longer lasting pressure resistance than the others under high temperature and high pressure.

The packing materials as set forth in claim 1 and 2 are durable enough under high temperature and high pressure as well as under room temperature and lower pressure, and their high lubricating ability (for lower torque) long lasts in the condition. Besides, because of no exposure of fibers of the plain state carbon fiber out of the surface of the packing material, there is no worn-out of a shaft where the packing material is used.

Therefore, the packing material can be used in either way for a valve or pump with high performance.

Any gland packing packed into a stuffing box can be made with just one type of the packing material, because of high performance in terms of pressure resistance, heat resistance and lubricating ability the packing material has.

The packing materials as set forth in claim 3 and 4 have further enhanced durability and can be used in higher pressure.

The gland packing as set forth in claim 5 to 8 are durable enough under high temperature and high pressure, and their high lubricating ability (for lower torque) long lasts in the condition as well as when it is used in room temperature and lower pressure.

Therefore, the gland packing can be used in either way for a valve or

pump with high performance.

Just one type of the gland packing is enough for use when it is packed into a stuffing box, because the gland packing has high performance in terms of pressure resistance, heat resistance and lubricating ability.